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EFFECT OF COPPER AND TITANIUM ALLOYS ON WEAR RESISTANCE OF CYLINDER SLEEVES

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The wear and tear on cylinder and piston rings is one of the more important factors affecting the longevity of motors. In the postwar years, our designers have devised a number of measures to reduce the wear on these parts. They include: (1) the manufacture of short cylinder sleeves from a special type of anticorrosive and antifrictional qualities; (2) coating the top piston ring with porous chrome; (3) chrome-plating the sleeves and cylinders; (4) the use of piston rings whose pressure distribution against the cylinder walls has been previously determined; (5) the use of fine oil filters; and (6) the use of thick-walled bushings in the crankshaft bearings.

All these improvements have proved their worth, as shown in the case of GAZ-51 and ZIS-120 truck motors, the longevity of which is greater than that of GAZ-MM and ZIS-5 motors. This justifies the experiments conducted in this field by the Gor'kiy Automobile Plant imeni Molotov, Moscow Automobile Plant imeni Stalin, and the TsNIIAT (Central Scientific Research Institute of Motor Transport), and described below.

In ordinary practice, capital repairs of motors follow a well-established procedure. Cylinders are subjected to repeated boring until they reach the required repair dimensions, after which cylinder sleeves of grey iron are inserted. These sleeves are usually cast by the centrifugal method.

However, cylinders repaired in this manner, i.e., through the insertion of grey-iron sleeves, are not sufficiently wear resistant to guarantee full runs between repair periods. Therefore, in 1947 - 1949 the TsNIIAT conducted a number of experiments in the First and Second Machinery plants to test the longevity of sleeves produced from medium-alloy iron with an admixture of BTML-3 (experimental) titanic and cuprous iron.

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To this effect, experimental sleeves cast centrifugally from medium-alloy iron with a 40-percent admixture of BTML-3 titanic and cuprous iron, and from grey iron, a product of the First Machinery Plant.

In this connection, comparative studies were also made of the qualities of the metals in regard to their total effect and their basic parameters. In particular, the following were determined: the iron's chemical composition; the nature of the basic metallic mass; the quantity, form, and distribution of the graphite and phosphide content; and the physical and mechanical properties of the iron.

The experiments were conducted with GAZ-MM motors, which had piston rings of grey iron, installed in passenger cars. To determine the wear on the cylinder sleeves, the following indexes were adopted:

1. Extent of wear in the cylinder sleeves as shown in various sections parallel and perpendicular to the axis of the crankshaft.

2. Mean maximum elliptical distortion of the cylinder.

3. Extent of wear in the first compression ring with respect to weight, thickness, height, accumulation of dirt in the lock, and loss of resilience.

4. Length of service of the cylinder sleeves and piston rings before a change of rings became necessary.

5. Extent of wear in the cylinder sleeves per 10,000-kilometer run.

6. Extent of wear of piston rings per 10,000-kilometer run.

Table 1 below shows the chemical composition of the iron used for the cylinder sleeves in the experiments:

Table 1. Chemical Composition (in %)

Material	C (total)	C (combined	Si	Mn	S	P	Ni	Cr	Cu	T
Grey iron, product of First Machinery Repair Plant	3.4-3.5	0.6	2.24	0.47	0.26	0.82	--	--	--	--
Medium-alloy iron with 40% admixture of BTML-3 titanic and cuprous iron	3.46-3.57	0.78	2.34-2.5	0.75-0.80	0.045-0.065	0.42	0.1	0.15	1.1-1.5	0.15-0.3

The BTML-3 iron used had the following chemical composition: C - 3.57; Si - 1.29; S - 0.014; P - 0.25; Cr - 0.26; Ni - 0.25; Cu - 3.6; and Ti - 1.1.

Both types of iron were subjected to mechanical tests, with the results indicated in Table 2 below:

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Table 2. Mechanical Tests

Yield Strength (kg/sq mm)

Material	During Stretching	During Compression	During Bending	Deflection (mm)	Brinell Hardness
Medium-alloy iron	22.1	96.3	49.3	1.4	229-269
Grey iron	12.0	73.5	36.6	1.0	170-219

All the vehicles were given three series of tests, each covering a run of 10,000 kilometers, and all were tested under analogous conditions. They were driven over asphalt roads 70-80 percent of the time and over cobblestones 20-30 percent of the time. Their daily runs were 120-130 kilometers. They were serviced in a manner usual for this type of vehicle. During the tests, the following factors were taken into consideration: the vehicle's daily run; the consumption of oil per shift and the periodicity of the shifts; the quality of the oil used and its condition during the vehicle's operation; the quality of the oil after it had been used; the motor troubles occurring during the operation; and the wear on the cylinders and piston rings, as measured by a micrometer.

As the table indicates, the mechanical qualities of medium-alloy iron are superior to those of grey iron.

An analysis of the data obtained shows that the wear on cylinder sleeves during the three 10,000-kilometer runs was equivalent to that occurring in the period between the changes of piston rings. Therefore, in the figures cited below concerning the wear on sleeves and piston rings, the period between the changes of piston rings has been chosen as a criterion since it also helps to determine the motor's period of service prior to the first repair period.

The results show that the wear on sleeves of medium-alloy iron is 1.6 times less than that on sleeves of grey iron. Moreover, the wear on the piston rings as a group, when used with medium-alloy sleeves, is 1.5 times less by weight. This figure holds true also for the wear in height and thickness, the clogging of the lock, and the loss of resilience. It is obvious, therefore, that between changes of piston rings, medium-alloy sleeves permit vehicle runs that are 1.6 times greater than those obtained with grey-iron sleeves.

The grey-iron sleeves required a change of pistons and two changes of piston rings during a 30,000-kilometer run, whereas the medium-alloy sleeves needed only one change of piston rings during an average run of 26,590 kilometers.

The mean and mean maximum elliptical distortion of cylinder sleeves occurring in 1,000-kilometer vehicle runs are shown in Table 3 below.

Table 3. Distortion of Cylinder Sleeves

Material used	Mean elliptical distortion per 1,000-km (microns)	Mean maximum elliptical distortion per 1,000-km run (microns)	Coefficient of comparison
Grey iron	2	3.1	1
Medium-alloy iron	1.3	1.9	1.6

As Table 3 indicates, medium-alloy iron is more advantageous since its elliptical distortion is 1.6 times less than that of grey iron.

An analysis of the wear on the pistons shows similar proportions. The average wear on aluminum pistons per 1,000-kilometer run is 2.2 times less than that on grey iron pistons.

The manufacture of cylinder sleeves from medium-alloy iron is also more economical. It has been established that expenditures covering the repair cycle (capital and medium repairs), including the cost of pistons, piston rings, and piston pins, amount to 42 kopecks per 100-kilometer run for medium-alloy sleeves and 73 kopecks for grey-iron sleeves.

Therefore, medium-alloy sleeves may be successfully employed in making capital repairs. The centrifugal casting of such sleeves offers no special difficulties and does not differ, insofar as techniques are concerned, from that of grey-iron sleeves. This has been proved at the Second Machinery Repair Plant.

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